VOLUME V #3 OCTOBER 1989 PRICE $3.50

FOR THE DESIGN, CONSTRUCTION AND ENJOYMENT OF UNUSUAL SOUND SOURCES

EXPERIMENTAL MUSICAL INSTRUMENTS

IN THIS ISSUE

LOTS OF GOOD THINGS

The stone and skyline image below represents a part of the **Wave Organ**, a sound environment designed by sculptor Peter Richards. It is one of several environmental sound sculptures created in recent years under the auspices of the Exploratorium science museum in San Francisco, and featured in this issue's article by Ann Chamberlain, starting on page 6. Additionally in this issue we have a report on harps and zithers designed by John Maluda for the tiniest of school children. It begins on page 20.

And herein you'll also find more swung music. In this installment swung music leads us to an investigation of the unprecedented and utterly unique acoustic system employed in corrugated tube instruments. Let's take a moment more now to acquaint or re-aquaint ourselves with this last topic before going on to the main articles.

In the foreground, listening pipes of Peter Richards' **Wave Organ**; beyond, the city of San Francisco. See article starting on page 6.

In the last issue we presented the first of a series of reports on instruments sounded by whirling or swinging movements. David Toop and Max Eastley's article, "Whirled Music", described a diverse and imaginative assemblage of such instruments, both traditional and new, used in performance by an ensemble devoted entirely to whirlables. In this second stage of the series we focus on one particular whirled instrument type: Whirlies.

If you don't know what whirlies are, it may only be because you don't know them by that name. No universal term seems to exist. The reference here is to the flexible corrugated plastic tubes, usually a little over an inch in diameter and about three feet long, which sing the tones of the harmonic series when held at one end and whirled overhead. They are often found in

(continued on page 10)

PLEASE CONTINUE TO INCLUDE articles on small, simple, easy-to-reproduce instruments for children. I feel that teaching children the rudiments of sound is important to promoting a future appreciation of all music, and would like to see more articles aimed at small-time experimenters who work with children. (Namely, me!)

Also, would you consider publishing a dictionary of terms used in the world of experimental music on a one-time basis? It took me a while to figure out what was meant by 'just intonation' and a few others.

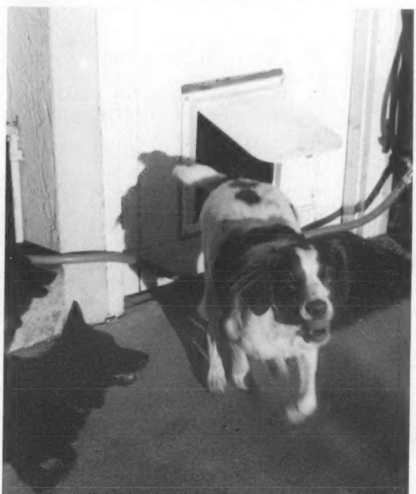
The musical scale chart is priceless!

Patrick Hough

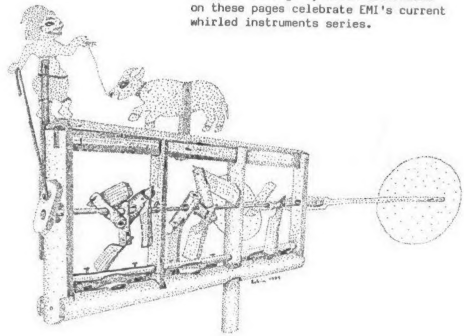
I RECALL YOUR AMBIVALENCE (if that's not too strong a word) to long-string instruments. Well, I just discovered a long wind instrument in my back yard. I recently installed a "dog door" between my garage and backyard, which has a magnet to keep it shut when not being traversed. It swings freely (made of high impact plastic) in both directions whenever a dog passes, driven somewhat by the magnet. The air displacement/compression is enough to form a 2-3 Hz wave which literally permeates the entire house! Now, to find a musical application ... tuned flaps and a dozen musicians. The conductor stands, milkbone in hand.

Jeff Kassel

Penny, a Brittany, demonstrates the dog door/garage wind instrument, by starting the reed swinging. Dipper, a Schipperkee and more pianissimo player, looks on.



Stipple drawings by Robin Goodfellow on these pages celebrate EMI's current whirled instruments series.



I REALLY ENJOYED David Toop and Max Eastley's article "Whirled Music" [EMI Vol. V #2], and their comments on the extensive literature about the bullroarer reminded me of one other interesting reference. In 1893 British antiquarian Andrew Lang also turned his attention to this mysterious sound-source in his **Custom and Myth** (London: Longmans, Green & Co.). I'll quote these few lines from the early part of his chapter "The Bullroarer: A Study of the Mysteries"; they have an antique charm of their own.

> The common bull-roarer is an inexpensive toy which anyone can make. I do not, however, recommend it to families, for two reasons. In the first place, it produces a most horrible and unexampled din, which endears it to the very young, but renders it detested by persons of mature age. In the second place, the character of the toy is such that it will almost infallibly break all that is fragile in the house where it is used, and will probably put out the eyes of some of the inhabitants. Having thus, I trust, said enough to prevent all good boys from inflicting bullroarers on their parents, pastors and masters I proceed (in the interests of science) to show how the toy is made.
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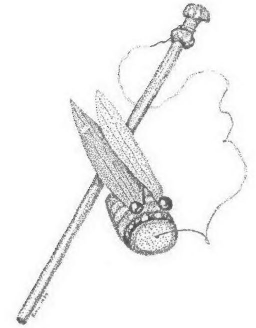
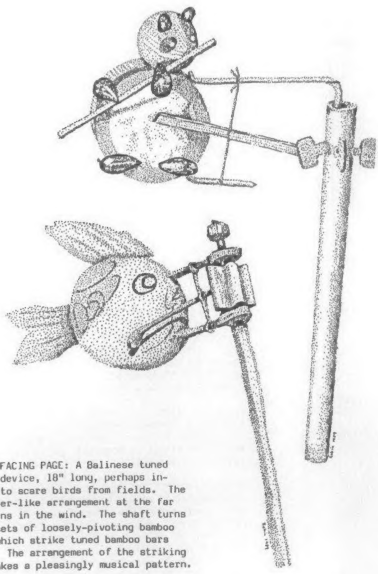
> * * *
>
> In a very interesting lecture delivered at the Royal Institution, Mr. Taylor once exhibited a bullroarer. At first it did nothing particular when it was whirled around, and the audience began to fear that the experiment was like those chemical ones often exhibited at institutes in the country, which contribute at most a disagreeable odour to the education of the populace. But when the bull-roarer warmed to its work, it justified its name, producing what may best be described as a mighty rushing noise, as if some supernatural being 'fluttered and buzzed his wings with a fearful roar.' Grown-up people, of course, are satisfied with a very brief experience of this din, but boys have always known the bull-roarer in England as one of the most efficient modes of making the hideous and unearthly noises in which it is the privilege of youth to delight.

(Lang's essay goes on to describe the bullroarer's use as a sacred and magical instrument among the Zuni and Australian Kurnai, its place in Dionysic mysteries and various African rituals.)

Lang's observations recall my own early adventures with a bullroarer, my earliest recollections of musical instrument invention. When I was around 7 or 8 years old, I spent my summers at a cottage built by my grandfather along Lake Michigan just south of Escanaba. One afternoon at the edge of the steps to the back porch, I had in my hand a piece of string attached to an oval-shaped piece of driftwood that moments before I had been towing around in the shallow water in pursuit of giant ore boats on the horizon. How it was that I began to spin this overhead I can't recall, but I vividly remember my initial shock and intense fascination with the noise that piece of wood suddenly and inexplicably gave forth. The powerful presence of this sound, beyond its ability to completely preoccupy my imagination and senses, quickly demonstrated itself to me when my grandmother rushed out of the back door to see whose car had pulled up in the driveway and now sat idling outside her kitchen window. She was not pleased to discover the source of the "awful noise" and brought an abrupt end to my bullroaring (before I broke something or put my eye out).





ABOVE, FACING PAGE: A Balinese tuned bamboo device, 18" long, perhaps intended to scare birds from fields. The propeller-like arrangement at the far end turns in the wind. The shaft turns three sets of loosely-pivoting bamboo arms, which strike tuned bamboo bars below. The arrangement of the striking arms makes a pleasingly musical pattern.

UPPER CORNER, THIS PAGE: A tiny whirled friction drum (handle about 6" high), recalling a cicada in sound and appearance. When it's whirled, friction between the string and its rosined groove in the stick creates a stick-slip vibration in the string. That vibration is communicated to the membrane head of the cicada at the other end.

IMMEDIATELY ABOVE: Two Chinese whirled cog rattles, each about 7" high. When the upper part rotates, the cogs displace and then release a small stick, held in place elastically by twisted string. The stick snaps back to strike the panda's belly or the fish's side.

There are many practical and playful reasons to tie a string to a small, flat piece of wood, and that is only a whirl away from the invention of the bullroarer. The simplicity of its construction belies the rich strangeness of its sound. Like the musical saw or mouth bow, the sound seems to have no connection to the physical object producing it; its call floats (or roars) like a disembodied voice. My grandmother was alarmed by the sound of a car racing its engine in the driveway. How must the bullroarer have sounded before such mechanical analogies existed?

As the axis of my own discovery of this mysterious noise, I had my own initiation into the pleasures of musicking, the power of musical sound to disrupt and transform the moment, as well as the social consequences of interest in unusual noises and inventions. From David Toop and Max Eastley's descriptions of the "strong visual and acoustic effects" of their whirled instruments, it is clear that the bullroarer retains into our adulthood in this rational and scientific age its commanding voice, its continuing power to signal profound alteration in everyday expectations as we venture into untamed realms. The call of the bullroarer speaks to our age with equal authority, resounding these words of naturalist John Muir: "A little pure wildness is the one great present want."

Hal Rammel

TIME TO RENEW?

If the expiration date on your mailing label is highlighted in yellow, then this is the last issue of your subscription. Please renew now -- we need you! (And you need us!) If you don't have our order form envelope on hand, just send $20 ($27 overseas), along with your name and address and a note indicating that this is a renewal, to EMI at PO Box 784, Nicasio, CA, 94946.

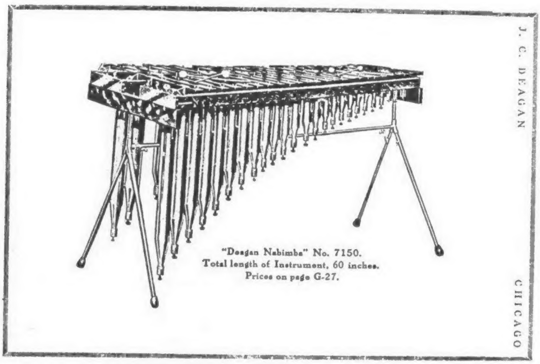
NOTES FROM RECENT CORRESPONDENCE

IN EMI'S LAST ISSUE we printed a letter from Blake Mitchell, responding to the previous issue's artitle on mirlitons. His subject was mirliton marimbas -- that is, marimbas with buzzing membranes attached to the resonators below the bars. Prominent among those he described was an instrument type once made by the Deagan Company, inspired by African mirliton marimbas. A drawing of that instrument, christened the **Nabimba**, appears in the fascinating collection of early Deagan Company catalogs recently reprinted by the Percussive Arts Society (**Percussive Notes Research Edition** Vol. 24, Numbers 3/6, March/Sept. 1986; 123 West Main St., Urbana, IL 61801). The illustration is reproduced below. Small cylindrical enclosures visible at the bottom of each resonator tube hold the mirliton membrane. The accompanying promotional description in the original catalog makes no mention of mirliton membranes, but refers elusively to "our very latest patented Nabimba resonators." It goes on to say, "The Deagan Nabimba has a tone impossible to describe and is unquestionably the greatest instrument of its kind ever put upon the market."

ALSO IN THE LAST ISSUE'S LETTERS SECTION were some notes from Hal Rammel, again written in response to the earlier mirlitons article. The article had spoken of an instrument called the bazooka, referring to it as a variety of kazoo. Hal's letter pointed out that "kazooed bazookas" were actually a popular offshoot of the original bazooka, which was itself not a kazoo. It was a sort of very short, fat trombone, apparently played by a combination of vocalizing and lip buzzing, and employing a slide. Musical comedian Bob Burns made, played and popularized it in the early parts of this century. Its sound seems to have struck people as inexpressibly funny.

Hal has since sent along this photograph of the offshoot instrument (below left) , the kazooed bazooka, complete with dummy trombone slide. Note the depiction of a bazooka virtuoso on the bell, and the instruction "Just Sing" (always good advice, with or without bazooka). Special thanks to the manikin who consented to model for the photo with a hand, incongruously enough, in perfect position for playing claves.

Drawing: The Deagan Nabimba, from an early Deagan catalog. Photo below: Bob Burns Bazooka.



EXPERIMENTAL MUSICAL INSTRUMENTS
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SUBMISSIONS: We welcome submissions of articles relating to new or unusual musical instruments. A query letter or phone call is suggested before sending articles. Include a return envelope with submissions.

LUTHEAL vs ORPHEAL: Hugh Davies sends this note following up one of the points in his article "Maurice Ravel and the Lutheal" in EMI Vol. IV #2:

The uncertainty over the difference between the lutheal and the orpheal mentioned at the end of my article on the former is partly clarified in Ernest Closson's book **History of the Piano**, originally published in Brussels in 1944. Closson, a specialist in the field (especially in Belgium), states that Cloetens devised both modified pianos, the orpheal imitating the sounds of the French horn, cello, etc. (unfortunately the book does not describe its mechanisms). This still does not explain why the instrument restored in Brussels has "orpheal" rather than "lutheal" inside its keyboard lid, for it is clearly a lutheal.

THE AMERICAN MUSICAL INSTRUMENT SOCIETY has recently printed a "Guide to Programs in Musical Instrument Related Fields." The four-page report was assembled by the society's Sub-committee for Student Concerns, with the purpose of compiling a list of academic programs in organology, museology and related fields. They discovered that, while individual courses in these areas are offered at many universities, only one formal program exists. That is the Master of Music degree program with a concentration in the History of Musical Instruments at the Shrine to Music Museum, University of South Dakota.

The report goes on to describe the USD program and then to list existing sources of information on schools for instrument building, museum studies, and general music programs. For additional information on the USD program or AMIS, contact Dr. Andre P. Larson, Shrine to Music Museum, University of South Dakota, 414 E. Clark, Vermillion, SD 57069-2390.

EMI BACK ISSUES

The issues of EMI Volumes III and IV are now no longer available individually in their original press runs. Like the issues of Volumes I and II, they will henceforth be available in bound, photocopied sets, at a price reduced to reflect the un-preferableness of photocopy. Even so, the bound sets are rather handsome, quite handy, and a good bargain. Here's the complete information:

Experimental Musical Instruments bound volume sets, each containing the six issues of the relevant volume year in photocopy, are $14 each. Four such sets are available: **Volume I** (June 1985-April 1986), **Volume II** (June 1986-April 1987), **Volume III** (June 1987-April 1988) and **Volume IV** (June 1988-April 1989).

Experimental Musical Instruments Volume V #1 and subsequent issues remain available individually and in the original press run at $3.50 each.

Cassette tapes **From the Pages of Experimental Musical Instruments** Volumes I through IV, each containing music of instruments featured in the newsletter during the corresponding volume year, remain available at $6 per cassette for subscribers; $8.50 for others.

CORRECTION

The stick figures seen dancing about the cover of our August issue were drawn by Max Eastley and not, as indicated, by David Toop. Apologies to all for the error.

SOUND FRAMES

Sound Sculpture at the Exploratorium Made by Doug Hollis, Peter Richards and Bill Fontana

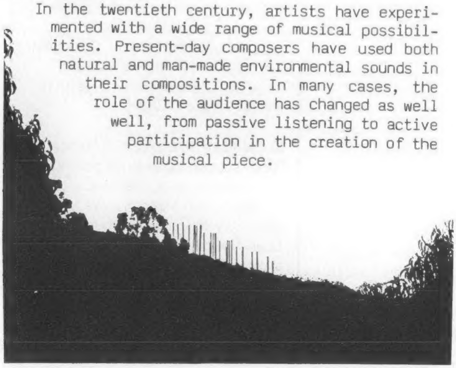
By Ann Chamberlain

San Francisco's Exploratorium is a hands-on science museum located in a cavernous, warehouse-like building adjacent to the city's Palace of Fine Arts. It has exhibits created by a diversity of scientists, technicians and artists, exploring aspects of light, sound, perception, electromagnetism, mechanics and the like. There is an unpolished, works-in-progress feel about the place; there are always new works under construction and the bustling work areas are within sight of the main exhibit areas. All in all, it's a great place.

In recent years the Exploratorium has sponsored a number of projects relating to sound and sound perception. Among these have been several environmental sound sculptures. This article presents work by Doug Hollis, Peter Richards, and Bill Fontana, three sound artists who have recently created sound works under the museum's sponsorship. The article first appeared in **Exploratorium Magazine**, and is reprinted here by permission.

John Cage once said, "The music never stops: it is we who turn away." This provocative statement raises many questions about the nature of music. Does it really exist all around us: Is a foghorn on San Francisco Bay as musical as a piano concerto? Can accidental noise or the natural sounds that surround us be considered music? If so, what role do we as listeners play? Is music in the ear of the listener? And does this mean that all aesthetic judgment is subjective, i.e., is a sound music because I say so? And if music exists around us, what role does the composer play?

In the twentieth century, artists have experimented with a wide range of musical possibilities. Present-day composers have used both natural and man-made environmental sounds in their compositions. In many cases, the role of the audience has changed as well well, from passive listening to active participation in the creation of the musical piece.



Bill Fontana, a San Francisco Bay Area sound artist, used foghorns in a work which addresses some of these issues. **Landscape Sculpture with Foghorns** drew its inspiration from foghorns, one of the constant aural motifs in the Bay landscape. Microphones were placed at eight locations around San Francisco Bay, picking up the sounds of foghorns from Angel Island to China Beach and Treasure Island. The sounds from the eight sites were broadcast outdoors at Fort Mason, within earshot of the foghorns and sight of the Bay. Since the audible sound traveled to Fort Mason much more slowly than the miked sound, the actual sound of the foghorns seemed to echo the broadcast sound, creating a disorienting spatial relation between naturally occurring and miked sound.

Fontana's initial interest in the change in sound with location came from his daily contact with his environment: "My concern for divergences created by changing audial perspectives did not arise out of wandering around concert halls during musical performances, but from wandering through everyday environments where it is the norm to be moving toward or away from sources of sound."

While Fontana and artists like him take sounds from the environment and shape them into musical compositions, other artists work more directly in the environment. Sound sculptures create a context in which the listener can perceive his or her own musical composition. The creation of such sculpture requires a clear understanding of the natural phenomena that activate sound (water or wind), a knowledge of the materials capable of activating the phenomena, a sensitivity to the site and its natural qualities, and an ability to frame this experience for the listener. This often means harmoniously blending both visual and sonic qualities.

Doug Hollis, artist-in-residence at the Exploratorium, created **Aeolian Harp**, which now hangs over the front portico of the museum. Irregularly grouped metal dishes amplify the sound generated by metal wires that are strung to airfoils on the roof. When the wind blows, the strings on the roof vibrate and transfer the sound to the metal dishes, creating a high-pitched, eerie hum. According to Hollis, **Aeolian Harp** works somewhat like a one-way tin-can telephone.

During peak hours at the Exploratorium, the sound of the harp becomes inaudible as it competes with the noise of visitors entering the museum. In the evening, however, when a breeze comes off the Bay, Aeolian Harp creates wonderful harmonies that reverberate inside the portico. You may have to listen closely to hear **Aeolian Harp** play: over the years since the harp was built, the eucalyptus trees on the west side of the museum have grown, blocking the path of the wind and diminishing the effectiveness of the harp.

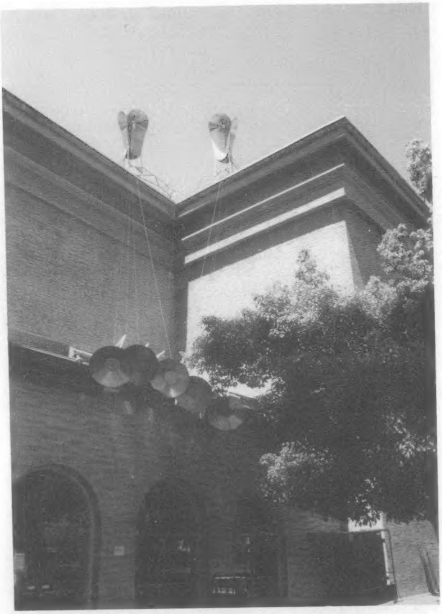
Another of Hollis' sound structures can be seen on the hill in front of the Lawrence Hall of Science in Berkeley. Entitled **Wind Organ**, the sculpture is a series of thirty-six aluminum pipes organized in a warped grid that moves down the hill, echoing the topography of the landscape.

 (continued on page 8)

IN SILHOUETTE, FACING PAGE: The upright pipes of Doug Hollis' Wind Organ, seen from a distance.

AT RIGHT: Doug Hollis' Aeolian Harp, over the entrance to the Exploratorium. The rooftop sheet metal structures serve as air foils. The dishes at the bottom amplify and radiate the vibrations of the strings excited by the breeze. The fundamental tones of the long strings are subsonic; what is heard, when the harp can be heard, are microtonal blends of overtones from high in the harmonic series.

BELOW: The Wind Organ, overlooking Berkeley and Oakland, San Francisco Bay, and, in the obscure distance, the city of San Francisco. The sound of the pipes is generated, flute-like, as an edge tone. The edge over which the wind blows is the rectangular slit near the top of each tube, most clearly visible in this photograph in the second pipe from the left. The edges are oriented differently from one pipe to the next, so that different pipes respond as wind direction shifts. The pipes function as open tubes, with the circular holes near the base of each pipe providing the distal opening. Those apertures also serve quite nicely as listening holes. (A disk inside each pipe just below the level of the hole marks the lower end of the vibrating tube length). The pipes vary in length up to about eighteen feet. The fundamental, low in pitch but well within the hearing range, is audible, especially for a listener with an ear to the circular hole. A wide range of harmonics are audible as well; they are more prominent than the fundamental for listeners more than a couple of feet away. Which harmonics sound most prominently depends upon wind angle and velocity at the edge. Between the shifting of the harmonics, the varied tube lengths, and the changes as to which tubes sound as wind direction shifts, the organ sings in a wonderful and ever-changing array of pitches. The shifting tones, mingled with the quiet roar of the city below, are moderately loud in a typical day's moderate wind. They carry well over distance, and are sometimes difficult for the listener to place directionally.



Photos in this article by Bart Hopkin

The wind plays these giant pipes in much the same way you play a flute. The tone produced depends on the length of the air column in the pipe.

Unlike traditional sculpture, Hollis' sound structures don't function as aesthetic objects in and of themselves, but are mediators or instruments intended to point out the phenomenon of the wind. Choice of site is particularly critical in such works. In considering his choice of sites for pieces and the sort of presence he wishes to create, Hollis states, "I sought out phenomenologically active places and then constructed pieces that celebrated what was already happening. Whereas a windy hillside is an undifferentiated situation, the presence of these sound-producing instruments creates a specific volume ... so that you feel like you're within the sound." The sound structure is a way of giving the dimensions of volume and sound to the phenomenon of wind.

Though Hollis' pieces play only when the wind blows, Hollis feels that the purpose of the piece is not lost if **Wind Organ** or **Aeolian Harp** aren't playing. The piece is a field or frame for other environmental sounds, requiring the perceiver not only to listen to the sounds generated by the instrument, but to tune in to the other sounds in the environment.

Hollis' sound structures break down the role of viewer/listener and encourage the audience to be participants, physically involved with using the instruments Hollis has created: "The idea of the viewer or listener is an objectification that I've been trying to work against for a long time. I refer to people that come to one of my works as participants. I try to dissolve the boundaries of 'me over here' and 'it over there' by making people a functional part of what is happening."

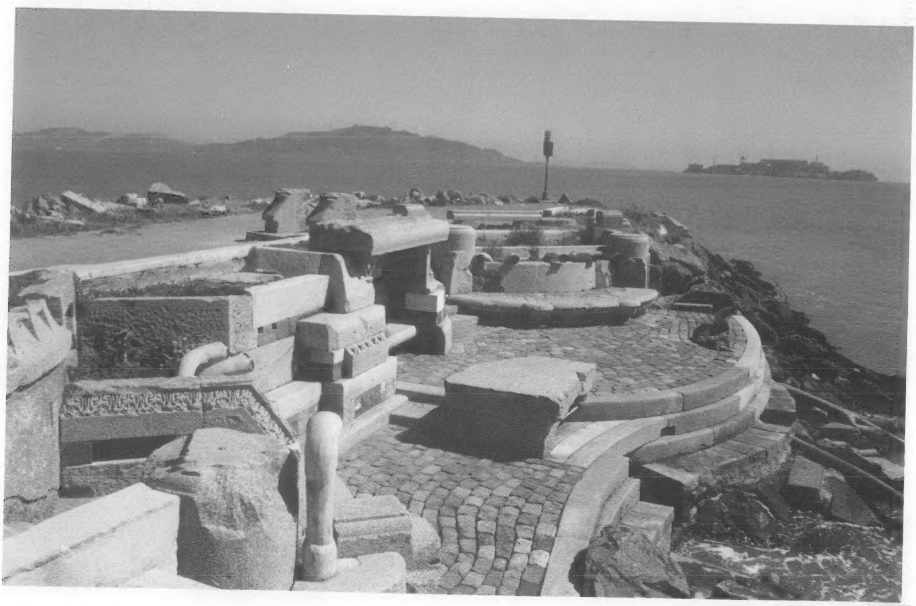
The most recent of the Exploratorium's sound sculptures is **Wave Organ**, created by Peter Richards with collaborator George Gonzales. **Wave Organ** uses water as a way of creating music. Situated on a jetty at the mouth of the marina, a ten minute walk from the Exploratorium, it celebrates one of San Francisco's special sites. Built in the form of a stone amphitheater or listening stage set into the breakwater, **Wave Organ** amplifies the sound of water rushing into PVC pipes as the tides ebb and flow.

The inspiration for this work came from Richards' experimentation with the **Pipes of Pan** exhibit at the Exploratorium. In **Pipes of Pan**, giant glass tubes or air columns resonate at different frequencies, with the longer ones creating tones lower than the shorter ones.

Richards was also inspired by Bill Fontana's recording of the sounds from a concrete pier in Sidney, Australia. A microphone installed in a pipe that vented the water chamber under the pier recorded changes in pitch and rhythm resulting from the wave action of the water.

In an attempt to replicate the sounds in the recording, Richards put tubes similar to those of the **Pipes of Pan** exhibit in the water of San Francisco Bay. The air columns within the pipes changed in length with the changing waves, and the resulting tones were higher when the columns were shorter and lower when the water emptied out of the pipe, lengthening the air column.

BELOW: Peter Richards' Wave Organ, with Alcatraz and Angel Island visible beyond.



The choice of the jetty as a site for **Wave Organ** was no accident. Richards' association with the jetty goes back to the first day he came to the Exploratorium in 1970 and walked out to look at San Francisco Bay. Initially, he wanted to work on the windward side of the jetty, but he found the wave action was so strong that the pipes became clogged with sand. After further testing, he found the right amount of wave action to be on the lee side of the jetty, facing the city.

This location also offered a beautiful view of the city and protection from the wind off the Bay. Richards terms the site, "a psychic refuge from the city. It's like being in an airplane: you get some distance and perspective on the city. You're out in the middle of the Bay in the natural world of birds, seals, and fish -- but at the same time you're looking at one of the densest urban environments in the country. I like that dichotomy."

The discarded stonework that litters the jetty -- including fragments of headstones and monuments from San Francisco's cemeteries -- had been a long-standing interest of Richards'. Several years ago he photographed and catalogued the various stone carvings with the idea of using them as material. George Gonzales, a skilled stonemason, has enabled Pete to realize this vision. Gonzales, originally trained in France as a stonemason, immediately appreciated the quality of work in the stone fragments on the pier and designed a stone listening room and benches to complement the **Wave Organ**. With the help of stonemason Tomas Lipps, crane operator and tinkerer Joe Tate, and apprentice stonemason Charles Whitefield, Gonzales maneuvered the stones, chipping and fitting them together. The result is a wonderful mixture of details and fragments from the past, reassembled into an outdoor listening room. It invites visitors to linger, listen, and reflect on the history of the area.

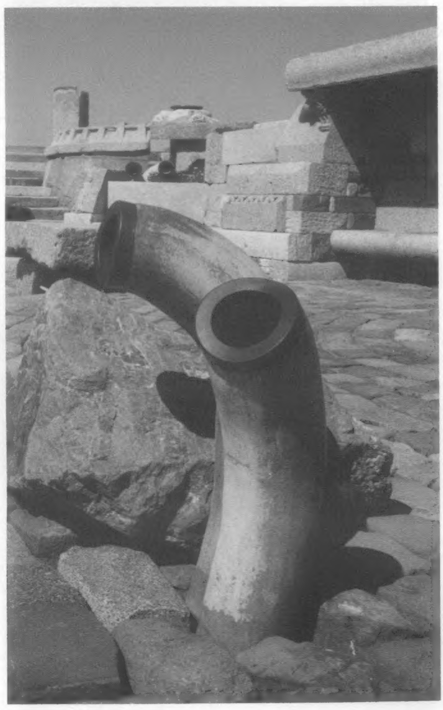
Most importantly, **Wave Organ** provides an arena in which the listener/participant can interact with the piece on many levels. Richards says, "**Wave Organ** is a destination, a place to go where things might happen. In creating a piece on this site, we've set a stage for a change in the perception of those who visit the jetty. We've made people comfortable in the environment by creating a place sheltered from the wind. From there it's up to people to explore. It's a rich environment. Different people will respond in different ways. Some people fish, other people neck, others read or listen to the pipes. The piece enhances and utilizes the energy of the ocean. It provides an avenue for reflection on everything from weather to the position of the moon and resonant character of enclosed spaces. Hopefully, people will listen to the water when they go to the beach. They'll be more aware of what they're hearing -- not just at the **Wave Organ**, but anywhere."

>

The Wave Organ, built on a breakwater in San Francisco Bay, consists of a sheltered public space on an upper level, the bay with its wave action below, and long listening pipes running between the two. The pipes have their lower openings at locations near or just below the point where the swells break on the rocks of the jetty (this is quite approximate, of course, since water level is always changing with the tides). The upper ends daylight at points in the amphitheater-like area above, where people can place ear to pipe to listen. The tidal sound from below retains fully its watery character, but is modified by the natural resonances of the long pipe. Those resonances shift as varying amounts of water rush in and out, partially filling the lower end.

The Wave Organ is more an environment than it is a musical instrument. The pipes don't turn water sound into music in a familiar sense. Instead they say, "Listen to the sound of the waves," and provide a highlighted time and place for the listening.

BELOW: Concrete-covered pipes reach for the water line below the people-area of the Wave Organ.
AT RIGHT: The listening ends of the pipes, externally shaped and finished in concrete to harmonize with the surrounding stonework, invite listeners.



The carefully crafted stone amphitheater and listening benches create a stage for the experience of listening. This meditative retreat enables the listener to pause and appreciate not only the sounds of the Wave Organ, but also a host of related environmental sounds: the lapping and gurgling of the water in the Bay as it washes against the jetty, the wind that passes, and the distant hum of the city that surrounds this small retreat.

The experience of listening to the **Wave Organ** can be compared to the visual paradox of figure/ground relationships, as shown by the Exploratorium's Vases/Faces exhibit. As your eyes shift between the black area and the white area, you see two faces or a vase, depending on whether you see the black as background and the white as object, or vice versa. When listening to the **Wave Organ**, we focus on the specific sounds emitted by the pipes. But as we continue to listen, other sounds of the Bay and the city become apparent. Sounds that were unnoticed in the background shift to become part of the foreground, and back again. As the sounds of the **Wave Organ** and the more random sounds of the environment fuse, we also develop an expanded perception of the sound environment around us as potential music, rather than as noise to be ignored. Listening to the musical resonances within the pipes enables us to perceive ambient sounds of the environment as music as well.

Richards' process of developing the **Wave Organ** articulates both a new kind of art/music and a new kind of artist/composer. In the collaborative process of **Wave Organ**'s construction, Richards saw his role as setting a goal for the project, but not controlling the contribution of theindividuals. "The richness of the outcome came from the group of people working together, their collaboration, and their interaction with the materials and the environment." Similarly, the music created by this piece has the potential for changing the way we perceive the environment. Listening to the **Wave Organ** is listening to the Bay and to the environment: it enables each of us to become instruments which are tuned to the world around us.

Sound sculpture, while utilizing natural phenomena and sounds found in the environment, does not eliminate the role of the artist/composer in forming the work: a foghorn can only be as musical as a piano concerto if it is perceived within the context of a musical composition. The sound sculptor/composer draws attention to a certain aspect of the environment, thus enabling the participant to perceive not only the sound of the sculpture but a host of other environmental sounds as a musical composition. Anything can be music if it is perceived within the frame of a musical composition.

PREFACE TO CURRUGATED TUBES, continued from page 1

the toy departments of five and dime stores. The sound of these fascinatingly simple devices is produced not, as people often initially infer, by the turbulence of air rushing across the edge of the tube at the whirled end. Rather, it is a product of periodic disturbances caused by the rapid flow over the corrugations within the tube as air is drawn in the near end and forced out the far end by centrifugal force.

No one has done more with whirlies than Sarah Hopkins. In her article on the following pages, she describes the various ways that she has used the instruments musically and in dance, and the various sorts of whirlies she has encountered or made along the way.

We follow Sarah's article with Frank Crawford's description of his Corrugahorns. "Corrugahorn" is the term Frank coined a decade and a half ago to refer to smaller diameter corrugated tubes, played not by whirling, but by blowing, wind instrument style. His article provides a full and lucid description of the acoustic system at work in both Corrugahorns and whirlies.

The singing of corrugated pipes appears to be a new phenomenon in music making. It doesn't seem to have been explored in previous generations, perhaps only because tubes with regularly spaced lateral ridges have only recently been widely manufactured. For a long time now this editor has been wanting to get some material on the subject into EMI. Now, finally, we have it. SO -- thanks Sarah Hopkins; thanks Frank Crawford.

Australian composer/ performer Sarah Hopkins with whirly instruments.

Photo by Impact Graphics.

WHIRLY INSTRUMENTS

By Sarah Hopkins

Sarah Hopkins is an Australian composer-performer and community artist with a background in classical and contemporary cello performance. She has been working in the area of sound art since 1976 and has toured extensively throughout Australia, Britain, Europe and the United States performing her music. Sarah is committed to creating "expansive pure music: music which resonates with the northern Australian landscape." Her current sound mediums include cello, voice, whirly instruments and bells which are used in solo, collaborative and ensemble works.

"An ensemble of whirlies produces astounding musical patterns of vibrant clear pitch, sometimes hauntingly beautiful, sometimes dramatic, sometimes soft, sometimes strong and robust, but at all times inspiring and thought provoking."

-- **Northern Territory News**, Australia, December 1984.

Whirlies are musical instruments made from flexible plastic corrugated hosing of various lengths and diameters. They can be precisely tuned and played in a wide variety of melodic and percussive ways. The basic playing technique involves whirling them through the air at various speeds. As one increases the speed, the pitch rises through the harmonic series, providing an average of five separate notes.

I was first introduced to whirly instruments during 1982 by a composer friend, Warren Burt, who gave me a small commercially made whirly called a "blugal." It was about 800mm long with a 27mm internal diameter. At the time I remember him saying that they were very popular in the United States during the 1970s as children's toys, and also used for sound effects in theater pieces. I loved the purity of the whirly's sound, the physicality required in playing it and its accessibility as an instrument playable by everyone.

Keen to work more with these instruments, I searched high and low for commercially made whirlies to buy in Australia. With no success at that time I decided to make my own and began experimenting with different lengths and diameters of swimming pool hosing.

Initially I found some 25mm diameter hosing which worked well at around one meter long, providing me with "High Voiced Whirlies" comprising six harmonics (3rd to 8th) [see figure 1]. By cutting the hoses to different lengths I was able to tune them very precisely and began composing solo and ensemble pieces for them.

The first major piece I wrote for these whirlies was "Sunrise, Sunset: A Whirly Soundscape," composed in 1983 for a team of artists to perform for children in isolated Aboriginal communities in the Northern Territory.

Playing techniques included the basic whirling plus a number of semi-theatrical percussion techniques; rubbing and scraping corrugation against corrugation, which provided us with mosquito and cricket-like sounds, hitting the palm of the hand over one end, which provided a frog-like sound, and "snaking" the whirlies on the ground ... which provided a hissing sound as well as the visual image of a snake!

In 1984 I formed the Darwin Whirliworks Ensemble: a group of six musicians with widely differing musical backgrounds (folk, jazz, classical and contemporary). The aim of the ensemble was to explore and experiment with many forms of composition for whirlies, culminating in a public per-

FIGURE 1. AN ARRAY OF WHIRLY INSTRUMENTS (the matchbox at center shows relative size).

Left to right:

1 Deep Whirly Mother (32 mm diameter)

2 Deep Voiced Whirlies (in different lengths/tunings; 32 mm dia.)

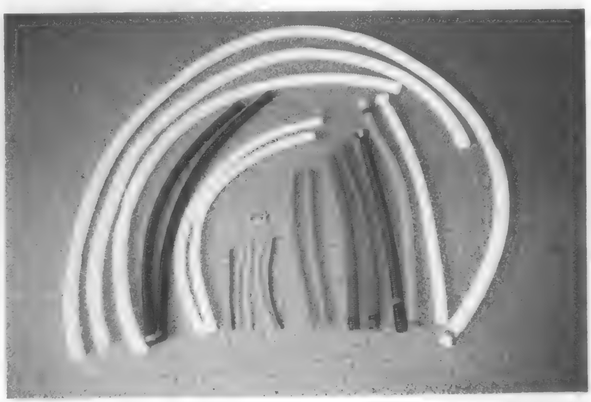
4 High Voiced Whirlies (2 black & 2 white; 25 mm dia.)

5 Whirly Whistles (7 mm dia.)

2 Dolphin Callers (15 mm dia.)

5 Colored Whirlies (assorted lengths/tunings; 27mm dia.)

Photo by Sarah Hopkins



formance of original music.

Whilst working on this project I found some 32mm diameter hosing which provided me with a whole new family of deep voiced whirlies. From 1.17 meters to 2 meters long these Deep Whirlies produce the most glorious rich tone. Each instrument is capable of playing beautiful five note melodies (from the 2nd to the 6th harmonic at 1.17 meters and the 4th to 8th at 2 meters). These Deep Whirlies are ideal for long sustains of single pitches. Inspired by this new instrument's rich tone I composed **Interweave** for six players and six deep whirly instruments.

Interweave is an expansive, meditative work which employs the layering of long sustains of sounds. The resultant sound image is very pure and quite hypnotic -- akin to the sound of Tibetan singing bowls. **Interweave** takes the form of a highly structured improvisation based on the following prose score:

"INTERWEAVE": Whirly Sound Fabric

One by one, as with single threads,
  weave together.
Nurture your sounds
  to their full vibrating sustains.
Listen always
  and work with the live fabric design,
(gently) interweaving your sound threads.
Allow the fabric breathing space -
But don't let all the threads cease "singing"
until the sound fabric is complete.

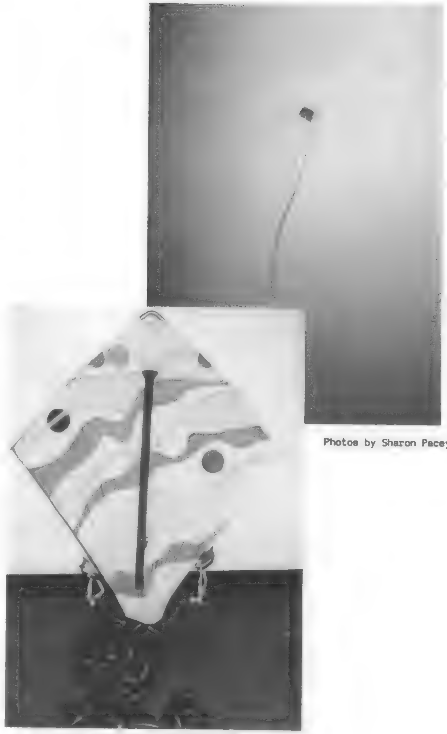
The score is accompanied by a set of specific and detailed technical instructions and the piece allows freedom for the performers to make it their own, whilst demanding interaction and creativity as they rehearse and perform.

In 1985, whilst on an Australia-wide tour, I came across two varieties of commercially-made whirlies: "Dolphin Callers," 15mm diameter, 540mm long toys which produce just two harmonics (2nd & 3rd); and "Plastic Sports Audio Pipes", toys made in Taiwan, 27mm diameter and 819mm long which comprise of six harmonics (2nd to 7th). The latter have an astoundingly pure tone ideal for both melodies and long sustains of sound. So far I have not used Dolphin Callers, but the Plastic Sports Audio Pipes, or Colored Whirlies (as I now call them), have been utilized in a wide variety of ways.

During 1985 Australian kite specialist Sharon Pacey and I used them in creating our most successful soundkite, the Singing Stunter. It is a dual control kite made from sail cloth and fiberglass with a whirly instrument attached to the kite's central spine. The whirly sings out loud and clear as the kite loops and dives in the sky [Figure 2].

In 1986, as part of an Artist-in-Schools project in Darwin, I used these Colored Whirlies in two ensemble pieces: **Eclipse** for 14 players using brass handbells and tuned whirlies; and **Bougainvillea Bells** for 14 players using handbells, tuned whirlies and cathedral bells.

Later that year I began creating a series of **Whirly Dances** with Melbourne-based choreogra-



Photos by Sharon Pacey

FIGURE 2 (above). The Singing Stunter Kite, designed by Sharon Hopkins and Sharon Pacey.

FIGURE 3 (below). Whirly Dance. Choreographer-dancer Beth Shelton with dancer Ian Ferguson and two Deep Whirly Instruments.

Photo: Timothy Newth

pher/dancer Beth Shelton. Our idea was to create works which involved the total integration of sound, movement and visual aspects with the whirly instruments being the focal and unifying element. Soundwise this integration was expressed through the dancer's use of whirly instruments as an integral part of the dance.

Compositionally it involved three distinct stages: First, the creation of a series of chord structures which would become the harmonic framework for the piece. Second, making the tuned whirly instruments to match these, and third, working hand in hand with the choreographer and dancers to create these truly integrated works.

In preparation for this work I experimented with all the whirly hosing and whirlies I had collected. Using the 32mm diameter hosing I made whirlies double the length of any I had made previously and to my delight came up with a range of beautiful deep whirlies which I call the "Deep Whirly Mothers." At 3.5 meters long a Deep Whirly Mother sings six separate harmonics (5th to 10th). When whirled gently it sounds like a deep wooden flute, singing gentle melodies over the six harmonics. As the intensity and speed of whirling is increased to its limits it literally roars like a strong wind.

In the Whirly Dances the integration of sound and movement was expressed in a variety of ways. For example, the physical challenge of playing a 3.5 meter long whirly instrument demands total body involvement; a oneness with the instrument. At times the unity was expressed through integrated overall spatial and sound patterns such as the "expanding chord spiral" which grew harmonically from the fundamental note in the center [Figure 3]. At times the movement phrases would dictate the sound phrases and at times the sound itself would be the focal element.

In the hands of dancers the whirlies took on a new lease on life. So far Beth Shelton and I have created four major Whirly Dances: "Wind Music for Earth and Sky" (1986) for seven whirly playing dancers (commissioned by Dance Works, Victoria), "She-Oak Sings" (1987) for three whirly playing dancers, "Sound Playground" (1987) for five whirly playing dancers (commissioned by Tas Dance, Tasmania), and "Play" (1988) for two whirly playing dancers as part of the 1988 "Sky Song" production [Figure 4].

During September 1988 I was engaged as "Performer in Residence" (with my whirlies and cello) at The Exploratorium, the museum of science, art and human perception in San Francisco.

Coupled with presenting a number of public lecture-demonstrations and performances I pursued several streams of investigative work with the help of Exploratorium staff. Investigating the physics of whirly instruments was a prime focus. In this area I received wonderful assistance from two physicists, Paul Dougherty (from the Exploratorium) and Frank S. Crawford (University of California, Berkeley), plus Exploratorium graphic artist, Diane Burke, who translated our findings into diagramatic explanations for teaching and display purposes [see page 19].

Paul Dougherty and I carried out various experiments with whirlies, at times using some of the latest computer technology, the Macintosh SE with the Macrecorder, Sound Edit and Sound Wave programs to facilitate sound spectrum analysis [figure 10]. Frank Crawford's contribution was also invaluable, especially his article written back in 1973 titled "Singing Corrugated Pipes" (published AJP Volume 42, April 1974; see also his article, containing much of the same information, in this issue of **Experimental Musical Instruments**).

Also during that time I met California instrument builder Darrell DeVore, and his wonderful Spirit Catchers and Wind Wands. We spent a lovely afternoon together playing our various whirled instruments and dreaming of a time in the future when they might be combined.

With Darrell's blessings I embarked on just such a project, composing innovative ensemble music for 48 brass handbells, five large tuned wind chimes, singing bowls (California-made Quartz Crystal Temple Bells), whirly instruments, spirit catchers, wind wands, voice and cathedral bells. The project, titled **Heart Song**, will come to fruition in performances during September 1989 in Darwin, Australia, and the resultant music will hopefully be released on audio cassette soon.

There are currently five audio cassettes available of my solo, collaborative and ensemble music: **Soundworks 1, 2 & 3** (released 1985), and **Soundworks Performance** (released 1986).

Soundworks 3, subtitled Whirliworks Performance, is a recording of innovative ensemble music for whirly instruments.

For cassette order forms and further information write to Sarah Hopkins, Resource Recordings, GPO Box 4168, Darwin NT 0801 Australia.

"EXPANDING CHORD SPIRAL"

- excerpt from Whirly Dance "Wind Music for Earth and Sky"

Seven dancers, numbered 1 to 7, using seven "G" whirly instruments.

All standing close together facing the centre of the space. Dancer 1 begins playing the low "G"; Dancer's 2 to 7 take one step out; Dancer 2 plays the "D" and stays in position whilst Dancer's 3 to 7 take one step out; and so on, expanding to form both a sustained "G" major chord and a spiral floor pattern.

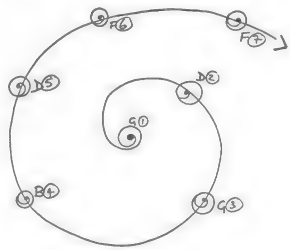


FIGURE 4

WHAT IS A CORRUGAHORN?

By Frank Crawford

(THIS IS A CORRUGAHORN)

Drawing by Robin Goodfellow

Frank Crawford, author of the article that follows, is a professor of astrophysics at the University of California at Berkeley. Sometime around 1972 he became intrigued with the singing whirly tubes then becoming popular, and he began investigating their acoustic behavior. He soon noticed that a smaller diameter corrugated tube, played by lung power like a wind instrument, makes a remarkably effective and versatile musical instrument. Over the next several years he continued his investigation of corrugated tubes as acoustic systems, added several refinements to the wind instrument he now called a **Corrugahorn**, and developed his own skill as a Corrugahorn player.

Crawford originally wrote "What is a Corrugahorn" back in 1974 for a local review (now defunct) called **The Berkeley Magazine**, and his account is full of the color of the time and place. Informal style notwithstanding, the article remains a clear exposition of the acoustics of corrugated horns. For the current presentation, some information has been updated, some peripheral material has been omitted, and additional material has been borrowed from "Singing Corrugated Pipes," Crawford's slightly more technical report on the same subject which appeared in the **American Journal of Physics**, (AJP Vol. 42, April 1974).

Maybe you already know what a Corrugahorn is. Have you seen someone riding a bicycle along Telegraph south of campus tootling away on a weird looking pipe draped around his neck? That was probably me playing on my 36-inch F-Sharp Neck Corrugahorn and bicycling between my place on Carleton Street and campus, where I teach physics. Or if you were on the Avenue during the week before Christmas, you may have seen me playing and peddling my Corrugahorns. That was the week I learned that the best acoustical bandshell on Telegraph is the entrance to Vaughn's clothing store. Bank of America is also pretty good. That week I really learned how to play the 24-inch C-Sharp Corrugahorn Bugle by playing it six hours a day, learning how to do "finger flatting," and inventing a scale I call "Serbian Minor." Or you may have seen Corrugahorns mentioned in the "Science and the Citizen" section of Scientific American for June, 1974, which is just arriving at the newsstands as I am writing this article.

Well, alright, what is a Corrugahorn? For starters, it is a whole new family of musical wind instruments invented by me in the spring of 1973. I call it a Corrugahorn because it is made with corrugated brass tubing, and the corrugations are what actually generate the tones. They take the place of the reed in a clarinet, the buzzing lips of the trumpeter, or the sharp edge of the tone hole in a flute or recorder. Here is how it actually works: The air flowing down the tube (or up the tube -- you can either blow or suck!), bumps against the little ridges that are the corrugations. Depending on the air flow velocity you have a certain number of bumps per second. If you double the velocity (by blowing or sucking harder), you double the number of bumps per second. The number of bumps per second gives the frequency or pitch of the note. That's all there is to it!

Almost. From what I just wrote, you might think that as you gradually increase the air velocity the pitch would gradually increase, something like a siren. Instead, the Corrugahorn emits only notes that are natural harmonics of the tube's fundamental tone. As the air velocity is gradually increased, the Corrugahorn holds on to one harmonic, getting louder and louder, until suddenly it jumps to the next higher harmonic. It always emits that harmonic whose frequency is closest to the bump frequency of the air flowing in the tube.

How did I come to invent Corrugahorns? By stumbling around for a couple years, with one thing leading to another. It all started a few years ago with an acoustical toy known variously as the Hummer, the Freeka, and the Whirl-A-Sound. A physicist friend, Claude Schultz, told me about them and I soon got a hold of one. They were simply a corrugated flexible plastic tube about an inch in diameter and three feet long. When the tube is held at one end and whirled around your

head it emits a loud pure tone. The faster you whirl the tube the higher the pitch of the note. I was fascinated by these toys and simply had to understand them. I had no idea at all of inventing a new musical instrument. I played with those tubes off and on for about a year, and finally understood them very well.

First I noticed that the notes emitted were the natural harmonics of a tube open at both ends. I found that as I whirled the Hummer first slowly and then faster and faster, I could get harmonics 2, 3, 4, etc. up to a maximum of 7 with my arm about to fall off. (It was a long time before I noticed I could never get the fundamental, #1; and therein lies a fascinating tale that led to the Corrugahorn. Later.) Once I passed out 50 Hummers to my Physics 4C class and we all swung at once together, producing a grand chord with all the harmonics two through seven present simultaneously. (That happening was inspired by a remark by physicist Gene Rochlin, that he had seen in London a few years ago a production by Peter Drucker of "A Midsummer Night's Dream" wherein the fairies came equipped with Hummers and whirled them in unison while making magic.)

I found that if I hold the Hummer out the window of my car, with the end of the tube pointing into the wind, it starts to sing (Harmonic #2) at about 15 miles per hour. By about 35 miles per hour I get the fifth harmonic. I get the 11th harmonic at about 80 miles per hour.

I found that a smooth plastic tube will not sing. The corrugations are essential! I found that air flow, rather than air blowing past the end of the tube, is essential. The Hummer sings only if air flows through it. With both ends open the whirling tube acts as a centrifugal pump, slinging air out at the far end and sucking in new air at the end near your hand. If you close one end of the tube and whirl it, it does not sing. If you hold the tube at the center and whirl it there is no net air flow, although there is still an effective wind across the ends of the tube, the tube does not sing. If you enclose the end near your hand with a plastic bag full of air and then whirl, the tube sings until it has pumped the air from the bag. Then the bag gets sucked into the end, and the tube stops singing. If you hold the tube out of a car window turned sideways to the wind, the tube does not sing. (But the fundamental can be heard roaring! The tube is then operating in the "flute" mode, due to air blowing across the edge of the end of the tube.)

After many weeks of just playing around I formulated a simple theory of the role of the corrugations. It was simply that the note being sounded has frequency equal to the bump frequency of air flowing down the tube:

Frequency of sound = Bumps per second

Then I did some simple proportions to relate bumps per second to the air flow velocity (in inches per second), and the corrugation "thread pitch" (in corrugations per inch):

$$(1) \qquad \text{Sound frequency} = \frac{\text{bumps}}{\text{sec}} = \frac{\text{bumps}}{\text{inch}} \times \frac{\text{inches}}{\text{sec}}$$

Equation (1) says the musical pitch equals the corrugations (bumps) per inch of the tube, multiplied by the air flow velocity in inches per second. To see if my theory was right, I had to measure the frequency of the sound, the corrugations per inch, and the flow velocity, and see if they satisfied the equation. I measured the pitch using tuning forks of known frequency. I measured the corrugations per inch with a ruler. The hard problem was how to measure the flow velocity? After many unsuccessful schemes, spread out over many months, I hit upon a good method. It was while I was basking one Sunday afternoon in a large redwood tank full of hot water, that it dawned upon me that I should use the water! I dashed out of the tub and got a large cylindrical wastebasket about 15 inches in diameter, cut a 1-inch hole in its bottom, and stuck one end of a Hummer through the hole. Then I got back in the tub, and inverted the basket. By pushing the basket down or pulling it up, I used the water as a piston to force air through the Hummer. I found to my delight that I could easily get to the 11th harmonic, whereas I can only get to the 7th harmonic with great effort by whirling. Also, I could easily measure the rate at which the basket was sinking into the water, when I pushed it steadily so as to maintain a given note. Since I could measure the velocity at which the basket was sinking, I could easily figure out the air velocity in the tube. Let's see how that goes: The cross sectional area of the 15-inch diameter basket is larger than that of the 1-inch diameter Hummer by the ratio of the squares of the diameters, namely $(15)^2 = 225$ compared to $(1)^2 = 1$. When the basket moves down, say 1 inch, a certain volume of air is pushed out by the water. That volume is proportional to the area of the basket times the 1-inch push distance. That same volume of air has to escape by going through the Hummer. But that means, since the Hummer area is 225 times smaller, it has to occupy 225 times larger distance along the Hummer than along the basket. Thus, 1 inch per second basket velocity means 1 inch per second air velocity while in the basket, and 225 inches per second velocity while going through the Hummer. (Provided the air doesn't get compressed significantly in one or the other place.) I calculated from my Equation (1) that if my theory were correct then, to excite the fifth harmonic of the Hummer, I would need to push the basket at a rate of 1 inch per second. I marked off 12 inches along the side of the basket, laid my watch on the side of the tub so I could watch the second hand, got the basket moving so as to get the sound of the fifth harmonic, and timed it. It took 12 seconds to go one foot! It worked!

Besides confirming my theory, the inverted wastebasket water piston makes a nice musical instrument. I call it a Water Pipe. It sings beautifully with very little effort either pushing the basket down or pulling it up. With some practice, I can play bugle songs. The Water Pipe is enjoyable to play around a swimming pool or lake. In the summer of 1972, I made one from a large plastic garbage can. The can was big enough so I could get under it and walk around in chest-deep water near the beach, invisible to the external observer, emitting loud clear tones. This >

attracts many children and some fish. My favorite place to play the Water Pipe is still in a large outdoor Japanese bath, where it was invented.

When do we get to the Corrugahorn? Soon! I started writing an article to be submitted to American Journal of Physics, about my discoveries. ["Singing Corrugated Pipes," Am.J. Phys. 42, 278 (April, 1974)] While writing, I would think of new experiments to do, and I started getting more and more bothered about something: The fundamental note of the Hummer simply would not sing! The lowest note I could get was the second harmonic, either by whirling or with the water piston. Why? I hadn't the foggiest idea. Was there something special about the fundamental? For some reason, it occurred to me to lower the fundamental note by one octave, by joining two Hummers end to end to make a new Hummer 72 inches long. I found that this one would not sing until it got to the third harmonic! Neither the fundamental nor second harmonic would sing! So the fundamental must not be so special! So what would happen if I made a shorter Hummer? I cut eight inches off the end of a 36-inch Hummer. This 28-inch Hummer sang at its fundamental as well as at its higher harmonics! The fundamental can sing if it is a high enough frequency! I eventually found, experimentally, that you have to be above a certain frequency, 200 cycles per second, for a Hummer to sing, rather than be above a certain harmonic number. The 36-inch Hummer has fundamental 174 cps (cycles per second), too low to sing, but its second harmonic, at 2 x 174 = 348 cps, makes it. The 72-inch Hummer with fundamental of 87 (half of 174) couldn't sing, nor could its second harmonic, 174; but its third harmonic, 3 x 74 = 222 cps makes it. The 28-inch Hummer has fundamental of 220 cps and sings.

But why? In puzzling over this weird phenomenon -- won't sing below a certain frequency -- I somehow recalled that my friend, physicist Alan Portis, had used the words "turbulent air flow" when I first showed him a Hummer. I didn't know why he was saying those words, and it didn't register with me at that time, because it had nothing to do with my lovely Equation (1), which I had just discovered and experimentally verified. But my equation sure didn't explain why you have to be above a certain frequency to sing, and now Portis' words returned to me. I got the hunch that turbulence had something to do with the lack of singing below a given frequency. It seemed plausible that in order to excite the vibrational modes of the tube (the notes it sings, i.e., the harmonics), it is necessary to convert some of the energy in the air flow into sound vibration energy. Now, in the sound vibration in a given harmonic, the air makes small excursions back and forth along the axis of the tube. In smooth (non-turbulent) air flow, the air snakes along the tube, always moving in the same direction. It seemed plausible that in order to extract energy from the air flow, there must be turbulence, so as to break up the smooth unidirectional motion and convert part of it into the back and forth motion of sound vibrations. It turns out that turbulent flow is governed by something called Reynold's number, which I won't explain, except to say that Reynold's number is proportional to the flow velocity and to the tube diameter, and for turbulence you need Reynold's number to be bigger than 2000. So my guess was that for singing you need turbulent flow, so you need a big enough Reynold's number, so a big enough flow velocity, so a big enough bump frequency, so a high enough pitch. I checked this out by plugging the appropriate numbers into the relevant equations, to find that the hypothesis worked! I found that having pitch above 200 cycles per second in the Hummer was about equivalent to having Reynold's number greater than 2000!

Now comes my discovery of the Corrugahorn. In order to further check my theory about Reynold's number being crucial, I wanted to vary the tube diameter, and see how that affected the lowest pitch that would sing. So I got some corrugated brass plumbing pipe at a hardware store and did some experiments. I happened to stick it in my mouth. I found myself playing 12-Bar Blues! Thus, was born the E-Natural Gas Pipe Blues Corrugahorn. You see, the Hummer has such a large diameter, that it takes so much air to make it sing, that you cannot get much out of it with your lung power. The gas pipe takes less air and makes possible a wind instrument played by mouth. It was the going to smaller diameter to check Reynold's number that led me to the Corrugahorn!

Since that time, Spring 1973, I have experimented with all sorts of tube diameters and lengths and corrugation spacings and depths. The tubes I now use in the horns are custom made for me with exactly the corrugation depth and spacing that I specify, as well as the tube diameter. I no longer use gas pipe. If you buy gas pipe at a hardware store you can make your own horn, but it won't have as good tone as mine and it will be harder to play. I have also done a lot of experimenting with the flared bell out of which the sound emerges. I don't think I have reached the perfect shape yet, but I'm getting closer. [The standard Corrugahorn bells, arrived at by trial and error, were made from plastic bicycle horns, purchased from the manufacturer and sawed off at the appropriate point -- ed.]

The horns I sold on Telegraph in the week before Christmas were all "natural" horns, meaning that their notes are just the harmonic notes 1, 2, 3, etc., i.e., C, C, G, C, E, G, Bb, C etc. The smallest horn was a 24-inch C-Sharp Bugle, which plays harmonics 3, 4, 5, 6, 7, 8, 9, and 10. Notes 3, 4, 5, and 6 give all the Boy Scout and Girl Scout and Army Bugle calls. Then I also had two "Neck Horns," the 29-inch and the 36-inch. These horns are long enough so you wear them around your neck. No hands! You play this one while bicycling, walking, dancing, driving, or playing guitar. In fact it was my invention of the Neck Horns that led me to take guitar lessons. I needed something to do with my hands.

The natural horns are great. So were the natural French Horns of the Baroque period, with no holes or valves. But I wanted a complete chromatic scale. I spent some time trying to make a good valve Corrugahorn, taking old trumpets apart to use their valves. It worked, but the tone quality degenerated, and I have not yet got a valve Corrugahorn that satisfies me. I have also experimented with holes. They are promising, but

they have some notable disadvantages. Finally about January 1974, I realized that a slide, like a trombone, was the best solution. I built one and it worked beautifully! I now have two models of slide Corrugahorn; the 29-inch A-Major Slide Corrugahorn, which has the same natural notes as the 29-inch Neck Horn, but also gets all the sharps and flats in between the natural harmonics; and the 36-inch F-Sharp Slide Corrugahorn, which has the same notes as the 36-inch Neck Horn.

The slide consists of two smooth (uncorrugated) telescoping brass tubes, obtained from "hobby shops". The outer one (typically six inches long) is joined to the end of the corrugated brass tube. The inner one has the bell at its far end. There is a compromise. If the slide is too long then too small a fraction of the total tube length is corrugated, and the sound gets weak. If the slide is too short, the total length cannot be varied enough. (To lower the pitch by one half tone the total length must increase by about 6%.) To see how it works in practice, let us look at my favorite, the 29-inch model in A major. For this discussion we'll pretend it is in the key of C with the slide all the way in. The good playable notes, with harmonic numbers in parentheses, are:

G(3) C(4) E(5) G(6) Bb(7) C(8) D(9) E(10).

Now extend the slide about 2":

F#(3) B(4) Eb(5) F#(6) A(7) B(8) C#(9) Eb(10).

Now another 2" to get:

F(3) Bb(4) D(5) F(6) Ab(7) Bb(8) C(9) D(10).

The lowest note, (3), is very soft and I don't much use it. Note that starting with Bb(4) we have an almost complete chromatic scale up to E(10). The only missing note is the low C#. When I need that C# I play the D(5) position and finger-flat it down to C# (I'll explain finger flatting later). So I have a chromatic scale of an octave plus a diminished fifth (Bb to E). That is sufficient for many songs, though not sufficient to play classical flute of clarinet parts, which often cover more than two octaves.

The slide Corrugahorns are real musician's instruments. You can play any scale in any key. The tone is clear and beautiful. They take a little longer to learn than the natural horns, because you have to decide what to do with your hand -- move the slide or not.

How do you play a Corrugahorn? You just breathe in or out through it! More air volume gives higher pitch (remember?). Since you can either suck or blow, you never have to stop to grab a breath. You have no embouchure (lip muscle control) to learn, as you must in most other wind instruments. You only have to learn breath control, since the pitch is determined by volume of air flow. As you play the natural horns, you soon find that you are merely "thinking" the sound and out it comes without conscious control, as if you were singing or whistling. Your breath automatically sets itself to the right volume. With the slide horns, your breath also automatically sets itself, but you have to learn where to put the slide.

With all of the horns, the pitch also depends

Photo by David Young

Frank Crawford demonstrates the corrugated tube air velocity measuring technique with waste basket and tub. Notice the corrugahorn around his neck.

somewhat on the shape of your mouth cavity, just as for any wind instrument. For example, on the easiest instrument, the 24-inch Bugle, it takes some beginners one or two minutes to get the lowest note, harmonic 3. You have to drop your jaw and open up your throat, as if yawning. Recorder players do this without thinking twice. The pitches of the other notes can also be affected by your mouth shape. To get the correct standard pitch of a harmonic, you should not pucker as if kissing or whistling, since that will effectively lengthen the tube and will flatten (lower) the note. All that is needed is that the end of the tube in your mouth abruptly ends in a large mouth cavity, rather than be extended by a tube-like extension of the mouth, or be partially blocked off by the tongue. (Flatting the pitch by puckering can later be used as an intentional technique, to "bend" the notes in what I call "whistle flatting").

The natural horns will play other notes besides the natural harmonics. The physicist-jazz musician, Lee Schipper, showed me how to do what I now call "finger flatting"; by sticking one finger down the throat of the bell until the sound is almost ready to be choked off. One can flat the note by one half tone. French horn players do something similar with their fist in the bell. With finger flatting, one can play tunes in a beautiful minor scale I call Balkan Minor, that I invented while playing the 24-inch Bugle. French horn players can sharpen a note by one half tone, as well as flatten it. For a long time, I tried unsuccessfully to sharpen notes on the natural horns. Recently I discovered what I now call "palm sharpening", using the palm of one's hand. It is my hope that eventually I will be able to play a complete chromatic scale -- all the sharps and flats -- over most of the range of the natural horns, by using finger flatting, whistle flatting, palm sharpening, and -- just discovered a few days

ago -- tongue sharpening.

The tone of the Corrugahorn is clear and beautiful. Fourier analysis reveals that it is almost all fundamental, with practically no overtones. That is to be contrasted with, say, the flute, where there is a rich combination of overtones present for every note played. The Corrugahorn has a very "pure" sound; not rich, but pure.

A few more technical notes about Corrugahorns, their design and use:

The fundamental note and harmonics of a corrugated tube will be lower than those of an uncorrugated tube of the same length and diameter. The fundamental of a three foot whirly tube, for instance, is nearly a semitone below that of a similar smooth tube. This can be understood as a "loaded wave guide" effect due to the corrugations. One can either think of the corrugations as increasing the effective length of the tube, or as reducing the velocity of sound below its value in free space. The presence of the flared bell at the end of the tube also increases the effective length (as it does for any belled instrument), and slightly distorts the tuning of the higher harmonics as it affects them disproportionately.

Irregularities in the corrugations, or the presence of uncorrugated sections in the tube, can have adverse effects. The first Gas-Pipe Bugles that I made had a peculiarity: the sixth harmonic was slightly more difficult to sound than the fifth or seventh. The instrument tended to jump from five to seven, skipping six, when I increased airflow. I attribute that peculiarity to the fact that the entire length of the 20 inch tube was not corrugated. One end had 3.3 inches of smooth pipe; i.e., about one sixth of the pipe was uncorrugated. For the sixth harmonic, the pipe should be vibrating in six segments of equal length, with nodes between each segment. In the partially uncorrugated gas pipe, only five of the six segments were being excited by the airflow over the corrugations. Perhaps that is why the sixth harmonic was difficult to play. To check my theory I made a 20 inch instrument with the entire length corrugated. The difficulty disappeared.

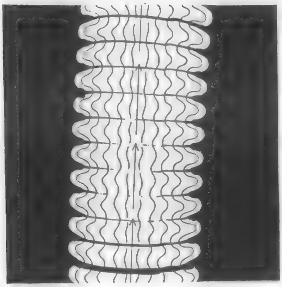
Contrary to experience with other wind instruments, making Corrugahorns of various tube lengths is not an effective method for creating instruments of different sounding ranges. Doubling the length will not allow you to play an octave lower. That is because the range of a Corrugahorn depends only on the distance between corrugations and the range of air flow velocities that can be produced by the player. This range depends on pipe diameter and lung capacity, and is nearly independent of length of pipe (except for the effect of friction, which is greater for the longer pipe). However, using a longer pipe does have the effect of locating the playable range higher in the harmonic series (since the fundamental -- probably unplayable -- is lowered while the playable range remains unchanged). Because the pitches of the series become closer together the higher in the series you go, this means that on the longer pipe more pitches are available within the same range. Thus, the 40 inch Blues Corrugahorn, capable of playing harmonics 4 through 16 over a fundamental of 165 Hz, has the same sounding range but plays twice as many notes as the 20 inch Corrugabugle, covering harmonics 2 through 8 over a fundamental of 330 Hz. I have tried an 80 inch Corrugahorn, with an expected range of harmonics 8 through 32 over a fundamental of 82 Hz. Unfortunately, it is very difficult, at least for me at this time, to sound one harmonic at a time on this extra long instrument. Several adjacent harmonics usually sound at once and the simultaneous sounding of harmonics 15 and 16 is not pleasing to most ears.

At present I am the world's greatest virtuoso on Corrugahorn. At least I was, until about a week ago when I sold a 29-inch A Major Slide Corrugahorn to a great reed musician, Roland Young, of the group, Infinite Sound, consisting of Roland Young and Glenn Howell playing all sorts of instruments, standard and exotic. Two days after selling Roland Young the horn, I went to hear Infinite Sound, at the One World Family place at Telegraph and Haste. I got a tremendous thrill when Roland Young played slide Corrugahorn on one number. He did things I couldn't dream of doing.

This instrument is just beginning to be explored. From French horn playing came finger flatting. A harmonica player showed me how to whistle flat, and it led me to discover palm sharpening. I'm still learning new ways to play it. When I get it into the hands of more great wind musicians like Roland Young, there will be new discoveries and new ways of playing it. Then I'll be learning from them instead of teaching. Meanwhile, it is the world's easiest wind instrument for beginners; easier, I think, than recorder because there is no fingering to learn, and easier than bugle because there is no lip control to learn. I have heard five-year olds tootling on the 24-inch Bugle with good pitch, playing bugle calls, after 10 minutes. I have also seen 35 year olds who never played any instrument, light up with pleasure when they heard pretty sound coming out of themselves so easily. (I have also heard people play weird unintentional pitches by unintentional whistle flatting and mouth cavity shaping. But it only takes a few minutes of teaching by imitation and telling them to reshape their mouth cavity, to get them to play the correct pitches.).

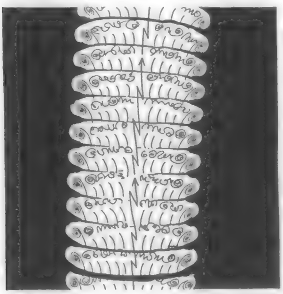
Meanwhile, you'll probably still see me riding my bicycle along Telegraph south of campus, tootling away on that weird pipe draped around my neck. But now you will know what it is.

Frank Crawford no longer makes Corrugahorns for sale. But for those interested in learning more about the instrument he can be reached at 2826 Garber St., Berkeley, CA 94705, telephone (415) 841-6481. The Corrugahorn has been used in concert by Peter Schickele (better known as PDQ Bach) and friends, and can be heard on an LP entitled, if memory serves, **Concerto for Weird Instruments.**



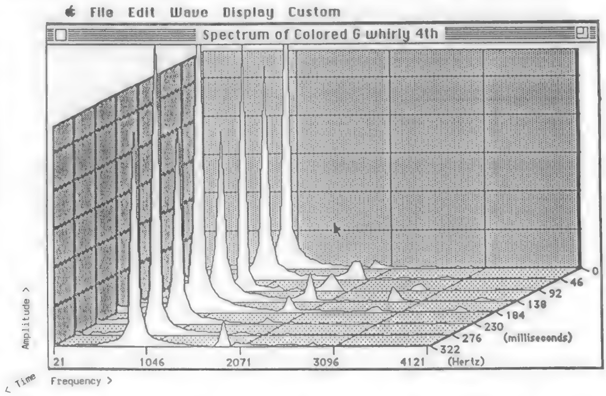
Laminar Flow

Smooth, or laminar, flow occurs when air moves slowly through the tube. During laminar flow, the whirly does not sing.



Turbulent Flow

The ridges in the whirly cause air to become turbulent when it reaches a certain speed. Only when the air is turbulent does the whirly sing. Turbulence makes the air move back and forth as it flows through the tube. This oscillating air creates the different notes you hear.



CORRUGATED TUBE NOTES FROM THE EXPLORATORIUM

Some aspects of corrugated tube acoustics described by Frank Crawford on the preceding pages are illustrated in these graphics, produced by Diane Burke and Paul Dougherty, working with Sarah Hopkins at the San Francisco's Exploratorium. At left, an illustration of the way audible vibration in the whirly tube appears only when air flow velocity exceeds a certain minimum, which may preclude the sounding of the fundamental or lower harmonics. Above, a Macintosh computer spectrum analysis for a whirly singing at the 4th harmonic, showing a single very strong basic pitch at that harmonic; other partials scarcely present.

JOHN MALUDA'S INSTRUMENTS FOR THE MONTESSORI CLASSROOM

By Bart Hopkin & John Maluda

Near the beginning of this century, the Italian educator Dr. Maria Montessori (1870-1952) began devising a comprehensive method for the education of very young children. At the heart of her thinking was a belief that children between the ages of three and six present a special window of opportunity for educators, regardless of the external circumstances of their lives. Montessori's method set out to teach very young children what we colloquially call the 3 Rs, plus basic nutrition, cleanliness, manners, and grace.

Also part of her program was music. Some years before Carl Orff came to a similar conclusion, Montessori wrote, "For the musical education we must create instruments as well as music" (from her first book, written 1909 and translated into English as **Montessori Method** in 1912). She also said, "I believe the stringed instruments (perhaps some very much simplified harp) would be most convenient," and "The stringed instruments together with the drum and the bell form the trio of classic instruments of humanity. The harp is the instrument of the intimate life of the individual."

In the years since those words were written, the Montessori method has grown into a worldwide institution, though the founder herself has passed away. The Association Montessori Internationale in Holland now coordinates practice of the Montessori Method. As for musical instruments in the contemporary Montessori classroom, the Association arranges for the manufacture of Montessori classroom materials, both musical and otherwise, through a firm called in Holland Nienhuis Montessori. Among its products is a special Montessori handbell set, as well as common childrens' percussion instruments like jingle sticks, wood blocks and castanets. Which of these instruments actually find their way into the music class depends upon the inclinations of individual music teachers. Instruments of other types and from other sources are not systematically excluded, and so may be used as well.

Along comes John Maluda. In 1965 Maluda, then working as a photo engraver, made a variation on a 27-string Irish harp for his 5-year old daughter. The instrument took a year to complete. Not long after, he came across a tiny violin in a music store, and learned for the first time about the Suzuki violin method. His daughter's harp teacher, knowing of Maluda's harp building experience, suggested that it should likewise be possible to make a small harp just for children. Maluda had previously seen and been much taken with some of equipment (most of it not musical) designed for use by children in the Montessori classroom. These several influences came together in the harp teachers' suggestion, and Maluda soon set out to design and build the "much simplified harp" that Montessori had spoken of, with the hope that it

Children's Harp by John Maluda, played by Benedicti Denoncourt.

Photo by John Maluda

would find a place in Montessori music classrooms.

His thought was to create something child-sized, and so simple in construction that it could be made on the kitchen table by an amateur woodworker. It would have to be strong enough to take the kind of rough handling that children are prone to give. For classroom use it would not need great volume, but it should preserve the simple beauty of harp tone. And the cost would have to be kept very modest. As his retirement approached and his time began to open up, Maluda researched the idea and began designing prototypes.

Montessori's sense that the harp would be an excellent candidate for children's music-learning was a good instinct, although she seems not to have been aware that there already exist many simple and beautiful folk harps in diverse traditional cultures. Diatonic harps are easy for a child to comprehend and easy to play in a rudimentary fashion (as opposed to instruments requiring bowing, fretting, or special embouchure). And they sound lovely.

Maluda's plans, while drawing inspiration from the world's folk harps, were not beholden to any particular tradition. His aim was simply to find the simplest and most functional possible form. He settled upon an unadorned triangular construction as seen from the side, with a near-triangular soundboard (slightly truncated at the top) as well. A simple triangular harp can be both sturdy (the triangle by its nature being the strongest basic design shape) and easy to construct, requiring no bending or special shaping. In the sound chamber, the absence of parallel walls inhibits the generation of standing waves and resulting wolf tones. The straight triangle is not the ideal shape for string scaling, but it is close enough for acceptable results.

Over a period of time Maluda built a number of small harps for classroom use. In the Hayfield Montessori School in Louisville, Kentucky, he found an opportunity to introduce them.

After working with the harps for several months, the instructors at the school suggested that for the tiniest children a still simpler string instrument would be valuable. In response, Maluda developed a small psaltery -- a 15-string zither that rests on a table horizontally before the child. It can have a music sheet with melody diagrams inserted over the soundboard directly below the strings.

It is the job of the International Materials Committee of the Association Montessori Internationale to oversee didactic materials for Montessori schools. In 1982, with encouraging results coming in from the harp and psaltery projects in Louisville and other Montessori schools, Maluda decided to seek official recognition. He submitted proposals for the instruments to the International Materials Committee. The response came back that the Maluda instruments could not be formally accepted, because only materials okayed by Montessori herself (who had by then ceased okaying things since she was no longer alive) could be recognized as Montessori didactic equipment. Maluda's reaction to this was to continue developing instruments for the Montessori classroom, without official recognition from or ties to the Montessori establishment.

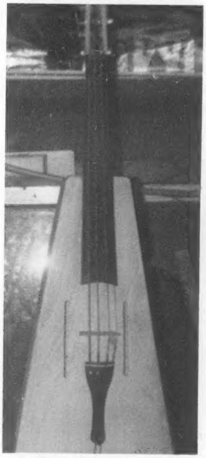
In the time since, Maluda has built about 60 harps and psalteries, and reached various stages of development with a number of other instrument types as well. As the work has progressed, his purpose has increasingly become the research of cultures past and present in search of musical instruments to adapt for children of three to six years old -- specifically, instruments which are simple, sturdy and highly functional in design; which are easy to understand and easy to play; and which can be built quickly and inexpensively without special tools or skills.

Descriptions of several of the Maluda instrument designs follow.

There are several harp designs, some of which are fancier than others. The simplest is an angle harp of about two feet high (photograph on facing page), with 23 nylon strings (guitar strings can be used). It sits on the floor, and the child-player sits cross-legged before it, tilting it back against the right shoulder to play. The string spacing is relatively narrow, suited to small hands. The body is made from hard rock maple. The soundboard is 5-ply aircraft grade birch plywood, chosen as the most effective after experimentation with many diverse materials. Note names can be marked on the soundboard. It can be assembled from scratch for under $70. Humble construction notwithstanding, this instrument has an impressively strong, clear tone which compares quite favorably with small harps everywhere.

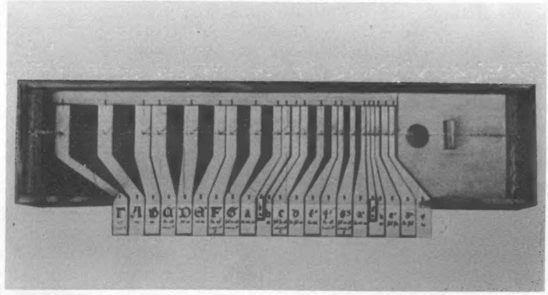
The psaltery (below) is a flat zither of about 2 feet long, 18" wide, and 2" deep, with 15 nylon strings. Maluda has developed simple notation sheets which slide under the strings, each sheet indicating the string plucking sequence for one melody. Hard rock maple, birch plywood and zither pins are again the basic materials. The sound is quieter and thinner than that of the harp.

The Maluda Psaltery

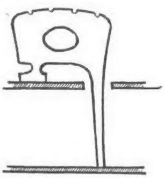


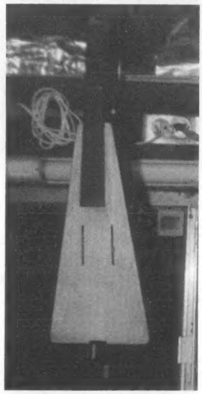
Prototypes for a simple children's viola (left) and violin (below).

Drawing below: The crwth-style bridge, designed to transmit vibration to both back and front.



Above: J.C. Neupert's reconstruction of the Von Zabern Clavichord (photo from Karl-Werner Guempel's article on the instrument).





Maluda has built prototypes for a Montessori fretted fiddle and viola, designed after the Savart instruments. Felix Savart (1791-1841) was an acoustic researcher with a special interest in the violin family. In connection with his experimentation he built a simplified violin of trapezoidal shape (coincidentally, very similar in soundboard shape to the Maluda harps). Maluda began work on his trapezoidal fiddles after consultation with Carleen Hutchins of the Catgut Acoustical Society. The Maluda design has a crwth-style bridge, with one long leg passing through a hole on the soundboard to rest on the back plate. The long leg functions somewhat analogously to a standard violin soundpost, transmitting vibration directly to the back as well as the face of the instrument. The soundboard is flat (lacking the violin's arch), and the f-holes, as with Savart's instrument, are replaced by two straight parallel slits. The linear design all around simplifies construction greatly as compared with the curves of the violin. The front and back are 1/8" 5-ply wood, and the sides 1/16" 3-ply. The viola is designed to be played by children da gamba (resting on the floor, cello style).

A single string clavichord is in the works. The design is based upon an instrument created by Conrad Von Zabern in the fifteenth century and used as an aid in practicing Gregorian Chant. The original instrument was researched by Dr. Karl-Werner Guempel of the University of Louisville School of Music. A reconstruction has been made in Germany by J.C. Neupert, described in Guempel's "Das Tastenmonochord Conrads von Zabern" (**Archiv fur Musikwissenschaft**, XII #2, 1955). The Maluda instrument will be 24" wide and 10" or so deep, with keys for two diatonic octaves. A single steel string will run the long dimension of the soundboard. The tangents for each key will strike it at the appropriate point to excite the desired sounding length and pitch. Such an instrument will be simple to construct and very easy to tune (just one string). It will also have the great pedagogic quality that its operation will be visible and easily understood, and it will observably manifest important basic musical principles.

The reconstructed von Zabern instrument is shown in the photograph above.

Full-size plans for John Maluda's harp and psaltery are available for U.S. $10 each. Maluda is no longer building production instruments himself, but the instruments are available from other builders whom Maluda can recommend. A video tape demonstrating the harp is available for U.S. $25. A limited-edition book containing full descriptions and plans for all the instruments is currently under preparation but not yet available.

For further information, write

John Maluda
1901 Ashmoor Lane,
Anchorage, KY, 40223.

NOTICES

"SINGING GLASSES: The Glass Harp: Liselotte Behrendt-Willach"; Quality cassette of classical and folk tunes by Europe's leading performer on glasses ground to pitch. $8.50; $1.50 S&H: Sampler Records, PO Box 19270, Rochester, NY 14619. 800-537-2755, Visa, Mastercard. Free catalog.

APPRENTICE SOUGHT: Sharon Rowell, maker of multiple-chamber ocarinas, needs someone to help meet current demand and possibly eventually set up an independent shop to meet future demand. The person will receive training and studio space plus opportunity for future independent work. Must have background in clay and music. 1061 Creston Rd., Berkeley, CA 94708.

MARIMBA BAR TUNING through the third harmonic; marimbas custom built and rebuilt; Helmholtz resonators made to order. MARIMBA ONE, PO Box 786, Arcata, CA 95521, phone (707) 839-5725.

EMI BACK ISSUES: Back issues of **Experimental Musical Instruments** numbered Volume V #1 and later are individually available for $3.50 apiece. Earlier issues available in volume sets of 6 issues each, photocopied and bound: Volumes I through IV, $14 per volume. Order from EMI, PO Box 784, Nicasio, CA 94946, or write for complete listing. Corresponding cassette tapes also available for each volume; see information below.

CASSETTE TAPES FROM EMI: **From the Pages of Experimental Musical Instruments**, Volumes I through IV, are available from EMI at $6 per volume for subscribers; $8.50 for non-subscribers (each volume is one cassette). Each tape contains music of instruments that appeared in the newsletter during the corresponding volume year, comprising a full measure of odd, provocative, funny and beautiful music. Order from EMI, Box 784, Nicasio, CA 94946.

TAPE EXCHANGE for airplay: "Hard Listening" is a new/experimental music program on Melbourne, Australia public broadcasting station 3PBS-FM. Show host Steve Charman is willing to swap tapes with composers/performers involved in making music suitable for airing on "Hard Listening." 87 Evans St., Brunswick 3056, Victoria, Australia.

JUST INTONATION CALCULATOR by Robert Rich. Composer's tool for JI. Internal sound for tuning reference; shows modulations; reduces fractions; converts between ratios, cents, DX7II/TX81Z units; MIDI tuning dumps. Requires Macintosh with Hypercard -- only $10.00. Soundscape Productions, Box 8891, Stanford, CA 94309.

MICROTONAL MIDI TERMINAL by Denny Genovese is a real time performance program for just intonation on virtually any MIDI controllable musical instrument; also a powerful tool for analyzing & constructing microtonal scales. System requirements: IBM PC, XT, AT or compatible with 128K, DOS, Roland MPU-401 or compatible MIDI interface, MIDI controller and MIDI controllable musical instrument. $50. Denny's Sound & Light, PO Box 12231, Sarasota, FL 34278.

TONY WELLS, musician and collector of eclectic instruments and music styles, including Waterphones, Tibetan Singing Bowls, Flutes and effects, presents in two cassette Albums. Approximately one hour each in length, COLLAGE and WEATHERSPACE are available for $10 ea., plus $1 for shipping and handling to Karma Productions, 701 Brush St., Las Vegas, NV 89107. (702) 870-8749. Also available for live performance. Send $2 for sampler tape.

BART HOPKIN IN CONCERT: In a reprise of a concert given in SF a year ago, EMI editor Bart Hopkin will play and talk about as many of his instruments as can fit in the back of his pickup, at the New Dance Palace in Point Reyes Station, CA, 8:00 pm, Friday October 13. Coinciding with the concert will be an exhibit of Robin Goodfellow's exquisite drawings of instruments from her extensive and exotic collection. Admission $3 (cheap). For more information call Bart at (415) 662-2182,

ALTERNATIVELY: Bart has recently put together a cassette tape of his own music, entitled "Ah, Wonderful Freddo." Anyone who is curious about what kind of music this guy does can send $6 to the EMI address, PO Box 784, Nicasio, CA, for the cassette. Truth in packaging disclosure / Warning to lovers of fringe music: The music on the cassette is not very way out; it's mostly based on familiar musical building materials. A number of unusual instruments appear, but mostly inconspicuously.

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Following here is a selected list of recent articles from other publications of potential interest to readers of **Experimental Musical Instruments.**

WHEN YOU CAN'T HEAR THE SHAPE OF A MANIFOLD by Carolyn S. Gordon in **The Mathematical Inteligencer** Vol. 11 #3, 1989 (175 5th Ave., New York NY 10010).

A highly mathematical description of nonexistent, theoretical instruments, postulated to have overtone frequencies that do not follow the integral multiple relationships of ideal strings and winds, but other, more complex formulae.

HARRY PARTCH: THE DREAMER WHOSE INSTRUMENTS STILL REMAIN by Gregory Tozian, in **Organica** Vol 8 #28, Summer 1989 (a quarterly distributed free through health food stores).

A general article on Partch, non-technical and assuming no prior familiarity with his work. It is well documented with references to the body of Partch's work, and made timely by observations drawn from a recent conversation with Danlee Mitchell, curator of the Partch collection of instruments.

ELEPHANT TALK by Katharine Payne, in **National Geographic** Vol. 176 #2, August 1979 (17th & M Sts NW, Washington DC 20036).

"While observing three Asian elephant mothers and their new calves, I repeatedly noticed a palpable throbbing in the air like distant thunder, yet all around me was silent." Thus the author describes subsonic vocalizations by elephants. Also included is a chart of animal vocalization frequency ranges in and out of the human hearing range.

HOW SADDLES CAN MODIFY TONE by Ken Donnell, in **String Instrument Craftsman**, Vol. 2 #10, Jul/Aug 1989 (20085 Stevens Creek, Cupertino, CA 95014-2307).

A violinmaker's approach to bridge shaping creatively applied to the shaping of guitar saddles to selectively modify tone.

SOME EXPERIMENTS CONCERNING THE EFFECTS OF SNARES ON THE SNARE DRUM SOUND by Douglas Wheeler, in **Percussive Notes** Volume 27 #4, Summer 1989 (Box 627, 123 West Main St., Urbana, IL 61801-0697).

This investigation demonstrates that engaging the snare drum snares does not alter the tuning of the fundamental of the drum, despite the fact that the change in timbre creates an impression to the contrary.

SOJIN PIANO -- PREPARING FOR THE PIANO MARKET'S NEW REALITIES in **The Music Trades** Volume 137 #6, July 1989 (address above).

Another in a series of articles in **Music Trades** in the form of a factory floor tour. A highly informative look, in both text and photos, at a modern, computerized and automated piano factory.

TIMBRE (PART I): THE ENVELOPE by David Courtney, in **Newsletter for Shastriya Sangeet** (Box 270685, Houston, TX 77277).

A brief introduction to attack, decay, sustain and release as components of sound envelopes.

INTRODUCTIONS PLEASE, in **Glass Music World** Volume 3 #3, July 1, 1989 (2503 Logan Dr., Loveland, CO 80538).

The introduction in this issue is to Gerhard Finkenbeiner, maker of glass harmonicas. The article traces his professional development as a glass worker and instrument maker.

AVEDIS ZILDJIAN: CYMBAL MAKING PIONEER, in **The Music Trades** Volume 137 #7 (PO Box 432, Englewood, NJ 07631).

A short biography of the member of the centuries-old family of cymbal makers who brought the ancient trade to the new world.

In **American Lutherie** Number 18, Spring 1989 (8222 South Park Ave., Tacoma, WA 98408):

STALKING NORTHWEST TONEWOODS by Bruce Harvie discusses North American woods used in string instruments, touching on various species of maple, and several softwoods suitable for soundboards.

TOWARD A CLASSIC GUITAR FAMILY by Graham Caldersmith is an account of his efforts over the last decade to create a classical guitar family of instruments, including a treble guitar a fourth above the standard guitar range, a baritone a fifth below, and a four-string bass an octave below. Repertoire is discussed as well as design and construction.

AN EXPERIMENTAL TENOR VIOLIN by Frederick C. Lyman, Jr. describes the building of a large da braccio violin, played under the chin, tuned an octave below the standard modern instrument. Lyman has some thoughtful comments along the way on how we decide what we are after timbrally in the process of musical instrument design.

Journal of the Catgut Acoustical Society Vol. 1, #3 (Series II), May 1989 (112 Essex Ave., Montclair, NJ 07042) contains several noteworthy articles:

WOODWIND DESIGN ALGORITHMS TO ACHIEVE DESIRED TUNING, by Douglas H. Keefe, discusses methods for predicting the acoustic behavior of proposed woodwind bore shapes and tonehole placements.

THE DYNAMICS OF MUSICAL STRINGS, by Maurice Hancock, discusses experiments revealing certain anomalous areas in which real string behavior is not in exact agreement with theoretically predicted results.

NONLINEAR BEHAVIOR IN OVERWOUND VIOLIN STRINGS, by Norman C. Pickering, discusses the relationship between playing tension and the tension that wound strings are subjected to during the overwinding process, and describes problems in vibrating behavior that arise if tension during winding is far greater than tension during playing.